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AN AREA CENSUS METHOD FOR ESTIMATING BUTTERFLY POPULATION NUMBERS.

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INTRODUCTION

KNOWLEDGE ABOUT POPULATION SIZE (or density) is often desirable in ecological and other studies in butterflies. Usually population numbers are estimated from capture-recapture data. Using this method it is possible to obtain accurate estimates of population size and also of birth and death rate. However, to obtain good estimates it is often necessary to capture and mark a large number of individuals which is a time-consuming task. Moreover the individuals captured may become disturbed resulting in unnormal movements and distribution patterns.

To avoid these drawbacks I proposed an area census method which is a line transect where the line covers the whole area inhabited by the butterfly population (Douwes, 1970). This method implies that all individuals observed are counted and that searching is carried out in the same manner in the whole area. In a population study of *Heodes virgaureae* (Lycaenidae) area censuses were compared with capture-recapture estimates and a high correlation between the two kinds of estimates was found provided that weather conditions were favorable when the censuses were carried out (Douwes, 1970). This promising result initiated further investigations to see if the area census method can be used for other species and by other investigators.

To test this, the size of two *Clossiana selene* populations (Nymphalidae) were estimated by three different persons using the area census method and the figures so obtained were checked against absolute estimates from capture-recapture data.

MATERIAL AND METHODS

Investigations were carried out in two areas E of Lund, southern Sweden, in 1969 and 1970. Each area consisted of meadow on dry to wet ground with *C. selene* concentrated to the wet parts. Both areas seemed to be isolated from other areas

suitable for *C. selene*. The area studied in 1969 was 50 m by 100 m; the area studied in 1970 was smaller and more irregularly shaped (Fig. 1).

Censuses were made on 7 (1969) and 16 (1970) occasions, each time by three observers (PD, GN and AO) all walking the same route (at a speed of approximately 1 m/sec.) that zigzagged through the area. The distance between a zig and the following zag was approximately 10 m. The situation in 1970 is shown in Fig. 1. To make things as equal as possible the three observers censused near each other in time, the first observer starting 2 min. before the second one, etc. Also the sequence of the observers was continually changed so that each started first, in the middle, and last the same number of times (not exactly, since 23 occasions is not exactly divisible by 3). The total population was estimated from capture-recapture data and the following procedure was followed. All three investigators moved together from one end of the area to the other and all *C. selene* encountered were caught, marked (if not already marked) and immediately released again. A felt-tipped dye pen was used for marking and each specimen was given an individual number on the ventral surface of the hindwing. Thus when recaptured the number had to be recorded only and no further marking was necessary. From the data so obtained population size with standard error was calculated by the method of Jolly (1965).

RESULTS

The numbers observed in the censuses and the absolute estimates are given in Table 1. There is a fairly high correlation between numbers censused and absolute estimates (Fig. 2), and also between the numbers observed by the different investigators the correlation coefficient being 0.88 between PD and GN, 0.82 between PD and AO, and 0.84 between GN and AO. The standard errors being only 6 to 19 per cent of the total estimates show that errors of estimates are small (Tab. 1). Thus assuming the conditions underlying the model are fulfilled, i.e. random sampling, a comparison of numbers censused with absolute estimates yields a reliable picture of the variation in the proportion observed in the censuses (within and between observers). The correlation coefficients mentioned above (Fig. 2) suggest that each of the observers censused a fairly constant proportion of the population. From the regressions in Fig. 2 it is obvious that there is a good agreement between the censuses

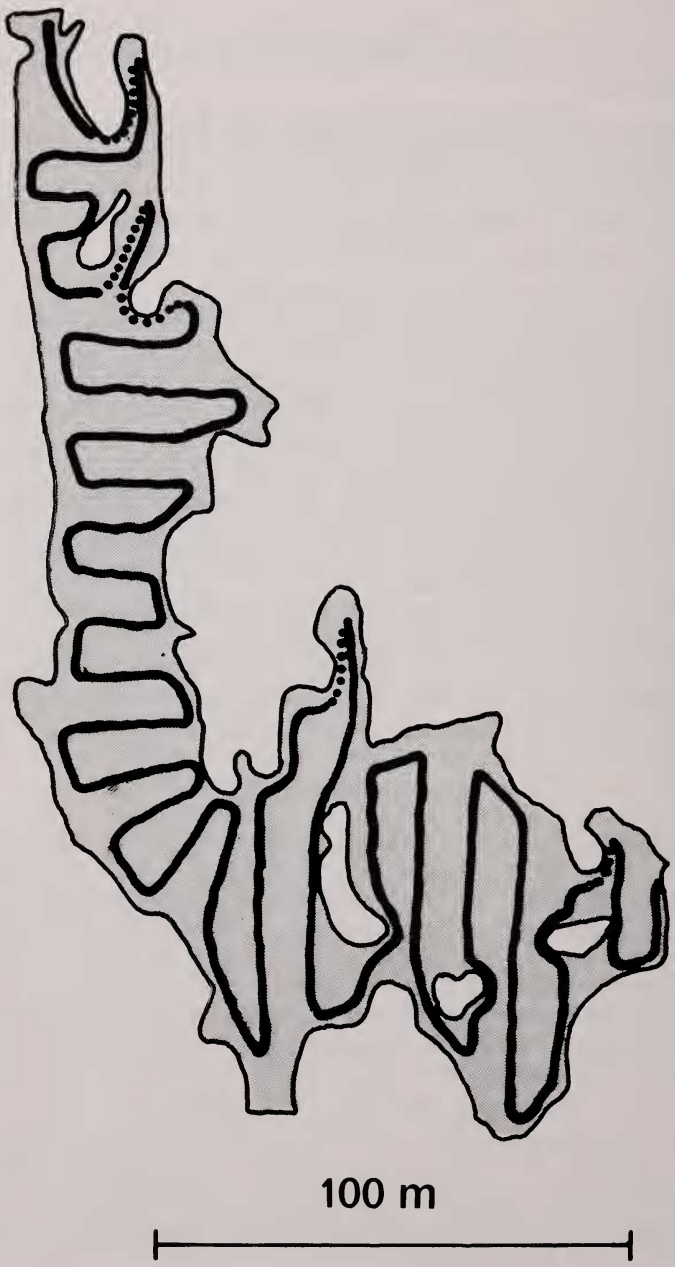

Fig. 1.—The investigation area in 1970 showing the route followed when the area censuses were made. Individuals observed along the parts of the route indicated by a broken line were not counted.

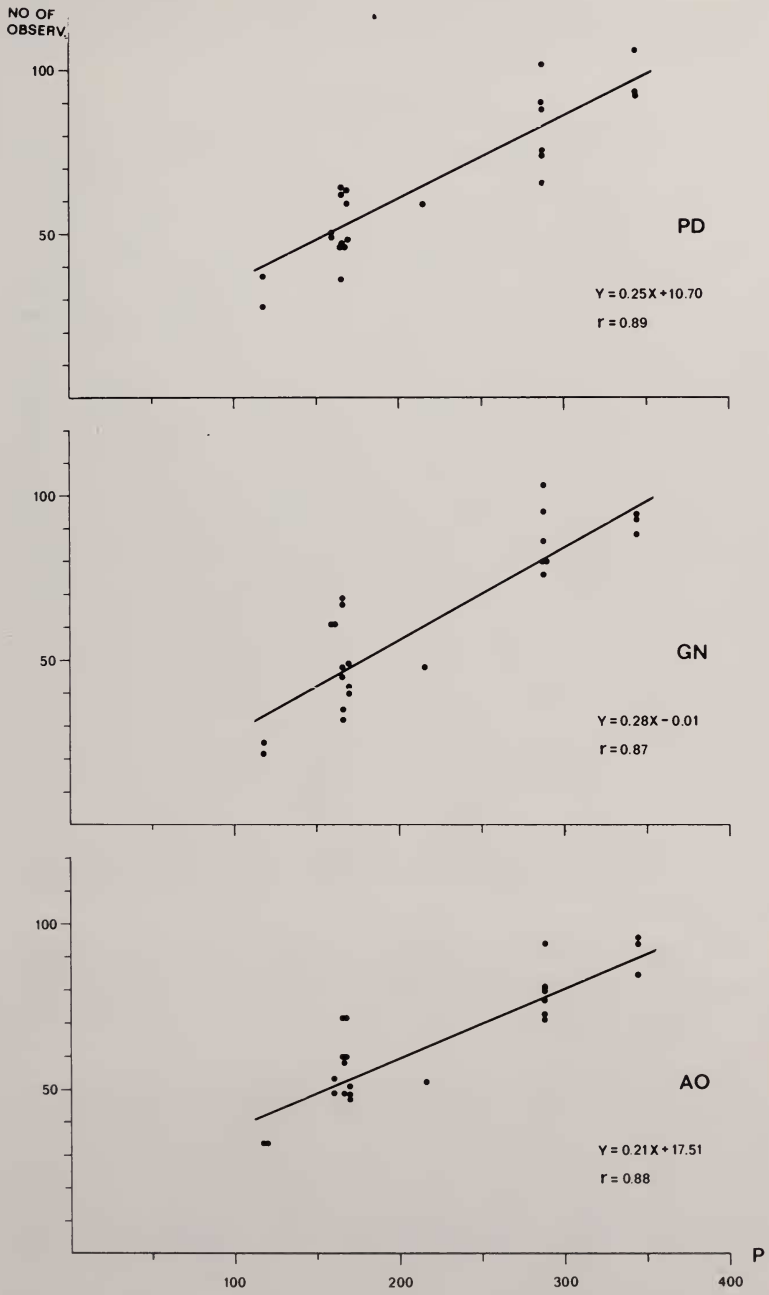

Fig. 2.—The number of observations of *C. selene* (area censuses) plotted against population size (P). Area censuses were made by three different persons PD, GN, and AO.

of the three observers all observing about 30 per cent of the population.

DISCUSSION

So far the area census method has been tested on two butterfly species and in both cases reliable estimates were obtained. Moreover the proportion observed turned out to be about 30 per cent in both *H. virgaureae* and *C. selene*. As to the former species the absolute estimates were erroneously regressed on the numbers censused (Douwes, 1970). Therefore, the correct diagram is given here (Fig. 3). Due to the high correlation between numbers observed and absolute estimates the conclusion previously drawn, i.e. that about one third of the population was observed, still holds. Common to *H. virgaureae* and *C. selene* is that they are rather sedentary and easily observed, two facts that make these species particularly suitable for censusing. The larger the proportion seen the less the variation in the estimate of the population size is. Censuses of more active species are probably less reliable because of multiple observations of individuals. A necessary prerequisite for this census method is that the species studied can be identified in the field. This is true for *H. virgaureae* and *C. selene* although the latter may occasionally occur together with other small fritillaries. In this study we observed a few worn and pale *C. euphrosyne* in the beginning of the investigation period in 1970 and at the end of the investigation in 1969 some *Brenthis ino* appeared which were somewhat larger and distinctly brighter than the no longer fresh *C. selene*. I believe that a trained observer is able to recognize most butterfly species in the field at least in northern Europe. Exceptions are *Pieris* spp., large fritillaries, and most blues.

Not tested here but certainly of great importance for the outcome of the census is the length of the census route per unit area. In this study the route length was 1.3 - 1.5 km/hectare (0.3 - 0.4 miles/acre).

The censuses of the three observers yielded very similar estimates indicating that inter-observer variation is insignificant provided that the censuses are made by trained butterfly observers which was the case in this study. However, the high degree of similarity in census results might to some extent be explained by a slight interdependence; the different observers walked exactly the same route and they may have adopted an unusually similar searching behavior.

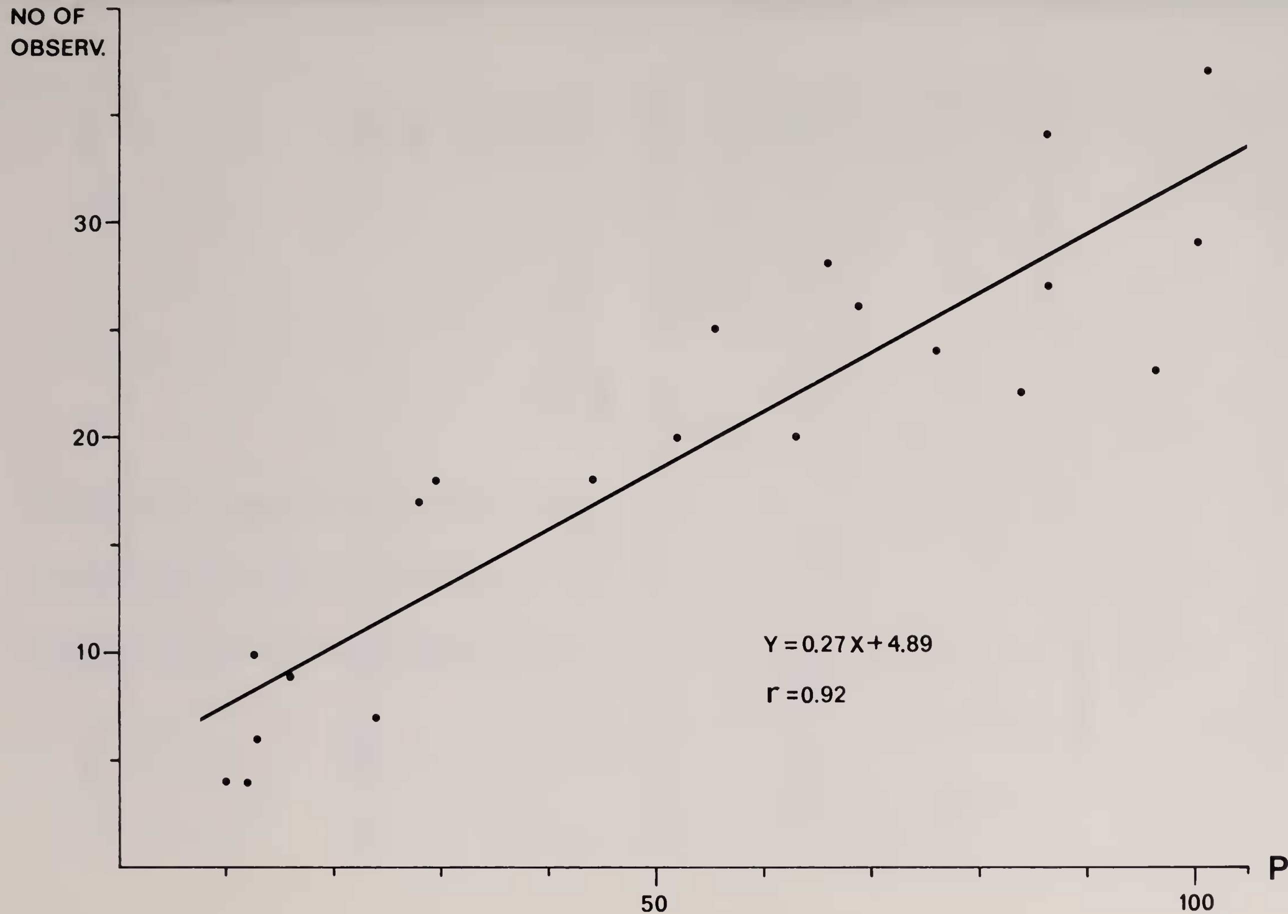

Fig. 3.—The number of observations of *Heodes virgaureae* (area censuses)

The time saved by the area census method as compared to capture-recapture is quite significant. For instance, for the population studied in 1970 a census took about 25 min., whereas for capture, mark, and release we used 2-3 man hours each time. Moreover to estimate the population size on x occasions, x censuses are needed but the butterflies have to be captured on x+2 occasions in a capture-recapture study.

In summary, the area census method seems to give sufficiently accurate estimates of population size in suitable species such as *H. virgaureae* and *C. selene*. Different census estimates made by one and the same person can be directly compared and possibly also censuses of different observers but this has to be tested further. I hope this paper will stimulate to further research in this field.

LITERATURE CITED

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Table 1. Area censuses by three different observers (PD, GN, and AO) and absolute estimates of two populations of *Clossiana selene* in 1969 (population 1) and 1970 (population 2).

year	date	area censuses no. of observations PD	GN	AO	absolute estimates (capture-recapture) total popul.	standard error
1969	26.6	49	61	53	161	24.7
		50	61	49		
	27.6	59	42	49	170	32.6
		63	49	51		
		48	40	47		
	3.7	37	22	34	119	20.9
		28	25	34		
1970	15.6	69	48	52	216	28.2
	16.6	57	45	49	167	13.7
		62	69	60		
		56	34	72		
		56	67	72		
		64	48	58		
		36	32	60		
	18.6	65	76	73	288	22.8
		75	80	71		
		88	80	77		
	19.6	74	86	94	288	23.6
		90	95	81		
		102	103	80		
	22.6	92	93	96	345	21.6
		106	88	94		
		93	94	85		